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REPORT

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the impairment caused by amplitude-perturbation of the colour subcarrier

No. 1970/2

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION

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(EL-36)

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SUMMARY

This report describes subjective tests which were made to determine the picture impairment introduced in the Mk 2A Field-Store Standards Converter when the quadrature-modulated intermediate chrominance subcarrier (which is of the NTSC type) is subjected to a systematic amplitude-perturbation, such as occurs in the converter. The tests showed that a perturbation of less than 1% is visible on a colour-bar test picture, a result similar to that of comparable tests with a monochrome signal to determine the impairment caused by switched amplitude-perturbations of the video signal.

1. INTRODUCTION

In a colour television system of the NTSC type, the amplitude of the colour subcarrier primarily determines the saturation of the reproduced colours but, because of the necessity for gamma correction and the consequent departure from the constant-luminance principle, it also conveys luminance information particularly in areas of highly saturated colour. In general, therefore, a change in amplitude of the subcarrier produces a change in both saturation and luminance of the reproduced colour picture. Amplitude errors of various types can occur in practice, of which constant errors, i.e. errors varying with the amplitude of the luminance signal level (differential gain) and random errors, i.e. errors due to noise are the most common. Information[1,2] is available concerning the permissible tolerances (determined from subjective tests) for all the above types of amplitude error but no such information appears to be available for errors which change in a systematic way and at a rate comparable with the line and field frequencies of the television signal. Errors of this type are possible in devices such as video tape recorders and field-store standards converters.[3]

This report describes an investigation carried out during the development of the Mk 2 Field-Store Standards Converter, to determine the subjective impairment caused by switched amplitude perturbations of the colour subcarrier.* In the Converter, a special 'intermediate' signal is used for transmission through a system of fused-quartz delay lines and it is the colour subcarrier of this signal which is subjected to amplitude changes as the delay lines are switched in and out of circuit. The colour subcarrier of the 'intermediate' signal differs from that of an NTSC signal in that the frequency has a whole-line, rather than a half-line relationship to the line-frequency and also that colour-difference (R-Y, B-Y) modulation, rather than 'I' and 'Q' modulation is used. Nevertheless, the effect of amplitude changes of the subcarrier would be the same as if it were an NTSC signal.

* Switched phase-errors of the colour subcarrier are also possible; these are the subject of a separate report.[5]

2. DESCRIPTION OF THE EXPERIMENT

2.1. Arrangement of Apparatus

Subjective tests were carried out using for convenience an NTSC type, 625-line, 50 fields/second television signal and the basic arrangement of apparatus used for providing switched small changes in colour subcarrier amplitude is shown in Fig. 1. The chrominance and luminance components of the video signal were separated by simple filters and the arrangement shown in Fig. 1 was inserted in the chrominance path. This split into two further paths, one of fixed

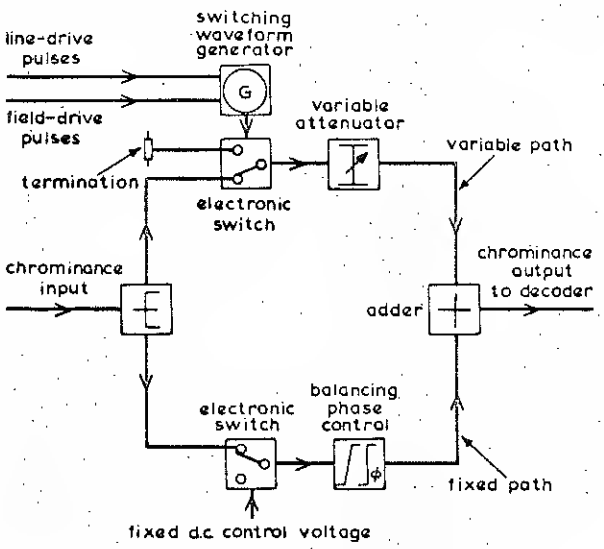

Fig. 1 - Arrangement of apparatus

gain and the other of variable gain and controlled by an electronic switch. The two signals were added in phase and by adjusting the attenuator in the variable path a small known perturbation of the subcarrier amplitude was produced as the electronic switch was actuated. Another electronic switch, biased to remain in one direction, was included in the fixed path to ensure that the amplitude and group delay characteristics were identical to those of the variable path, thus ensuring that the phase of the perturbed signal remained constant.

The active electronic switch operated during the line-blanking intervals and was controlled by signals from a special waveform generator. The control signals were rectangular, the rise and fall of any one waveform simulating the switching of delay-units in a field-store converter. As shown in Fig. 2, the waveforms were derived from line- and field-frequency pulses and simulated the control signals applied to the switches connecting main-store delay-units in an advanced field-store converter. (These delay-units form a sequence of multiples of T, where T = 66·2/3 μs for a field-store standards converter operating between 525/60 and 625/50 standards.)[3]

2.2. Nature of Picture Impairment

In general the picture impairment caused by the switched amplitude errors appeared as horizontal strips of erroneous saturation and brightness moving in a vertical direction. The main characteristics of the impairment pattern for each switching waveform were as follows:

Waveform 'A' : Narrow horizontal strips of enhanced saturation and brightness, changing position up and down cyclically at 5 Hz.

Waveform 'B' : Horizontal strips with a 25 Hz vertical 'judder'.

Waveforms 'C' and 'D' : Broad horizontal strips moving rapidly upwards.

Waveforms simulating the control of the remaining longer delay-units produced some horizontal strips with a 10 Hz vertical 'judder'.

Preliminary subjective assessments showed that for any given amplitude-perturbation, waveform 'A' produced a picture impairment pattern considerably more visible than any of the other waveforms. The subjective tests were therefore carried out using only this waveform.

2.3. Test Procedure

A group of five experienced observers was used for the subjective assessment of picture impairment caused by the switched amplitude errors. The group

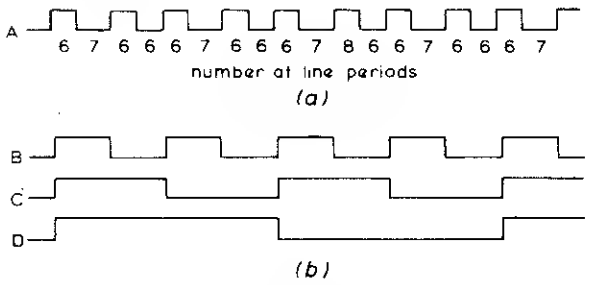

Fig. 2 - Switching waveforms

(*a*) Primary waveform derived from Line Sync Pulses. This sequence was continued throughout five fields and after five fields the sequence was restarted. (This simulated the action of the switch controlling the delay unit of delay T in a practical standards converter.

(*b*) Secondary waveforms derived by bistable counting circuits from A, B, C and D simulated the action of switches controlling delay units of delay 2T, 4T and 8T in a practical standards converter. Waveforms simulating switches controlling remaining delay units were obtained by further counting circuits working in a similar manner.

observed a colour television monitor having a screen diagonal of 0·64 m (25 in); the ambient illumination was such that the luminance of the unexcited monitor screen was about 0·14 cd/m^2 (0·04 ft-L) and the displayed white brightness was about 52 cd/m^2 (15 ft-L). The observers viewed the monitor from distances ranging from three to six times the picture height.

At the start of each test the observers were shown an unimpaired picture followed by a severely-impaired picture. They were then asked to assess the perceptibility of varying degrees of impairment using the EBU standard six-point impairment scale given below.

1. Imperceptible
2. Just perceptible
3. Definitely perceptible but not disturbing
4. Somewhat objectionable
5. Definitely objectionable
6. Unusable

2.4. Choice of Pictures Used for Tests

There were three tests each using a different test picture. In the first test an electronically-generated, full-amplitude, 95% saturated colour-bar picture was used. This picture, with its freedom from noise and its intense chrominance component, was extremely susceptible to subcarrier amplitude-errors and provided a particularly stringent test.

In the two other tests the picture source was a colour slide-scanner employing electronic masking to produce highly saturated pictures, typical of those obtained from a colour television camera. One slide was chosen which was particularly susceptible to the type of picture impairment under investigation and was therefore representative of the most stringent pictures likely to occur in practice. This, a standard EBU

slide, was a close-up view of a girl wearing a saturated red ski-jacket with a background of deep blue sky. The EBU description is slide 'USA 2, Gloved ski-girl holding pole.'

A second slide was chosen which was considerably less susceptible to the impairment and likely to be more typical of pictures occurring in practice. Again this was a standard EBU slide described as 'EBU 1, Boy with toys.'

3. RESULTS OF THE TESTS

Fig. 3 summarises in graphical form the results of the tests. 'Best-fit' curves are drawn through plots of points corresponding to the means of the grades recorded by the observers for each test condition. Fig. 3 shows, as would be expected, that the colour-bar picture is by far the most susceptible to switched subcarrier amplitude changes, the impairment being most visible in the red and magenta bars. If grade 1·5 is taken as a criterion, the permissible error for the colour-bar test signal corresponds to a perturbation of subcarrier amplitude of only about 0·7%. For a stringent picture 'Gloved ski-girl holding pole,' the permissible error is 1·7% whilst for a typical picture the permissible error can be increased to about 3·4%. It is interesting to note that these results are comparable with those from similar experiments with a monochrome system in which the amplitude of the video signal was subjected to switched perturbations.[6]

In addition to the tests with the specified viewing conditions a short investigation was made into the effect of changing from normal the brightness and contrast settings of the colour monitor. Within the range of settings giving acceptable viewing conditions of the 'Boy with toys' picture it was found that the curve shown in Fig. 3 could vary by about ± 1/4 of a grade for small amplitude perturbations (2–3%), increasing up to about ± 1/2 grade for larger perturbations. Clearly, to achieve consistent results in experiments of this type, close control of viewing conditions must be maintained. Domestic viewing conditions, on the other hand, are not subject to the same degree of control and the results given in this report must accordingly be interpreted with caution. In the design of the Field-Store Standards Converter a target figure of 0·5% maximum amplitude perturbation was used.

A check was also made on the effect of subcarrier amplitude errors on the compatible monochrome picture. This was found to be similar to that on the corresponding colour picture, the impairment taking the form of horizontal strips of enhanced brightness due to rectification of the subcarrier. The monochrome check was made with a picture monitor having a full-amplitude response at subcarrier frequency. The response of most domestic monochrome receivers however is considerably reduced at the subcarrier frequency so that, in practice, the effect of subcarrier amplitude perturbations would be much less visible than on a colour receiver.

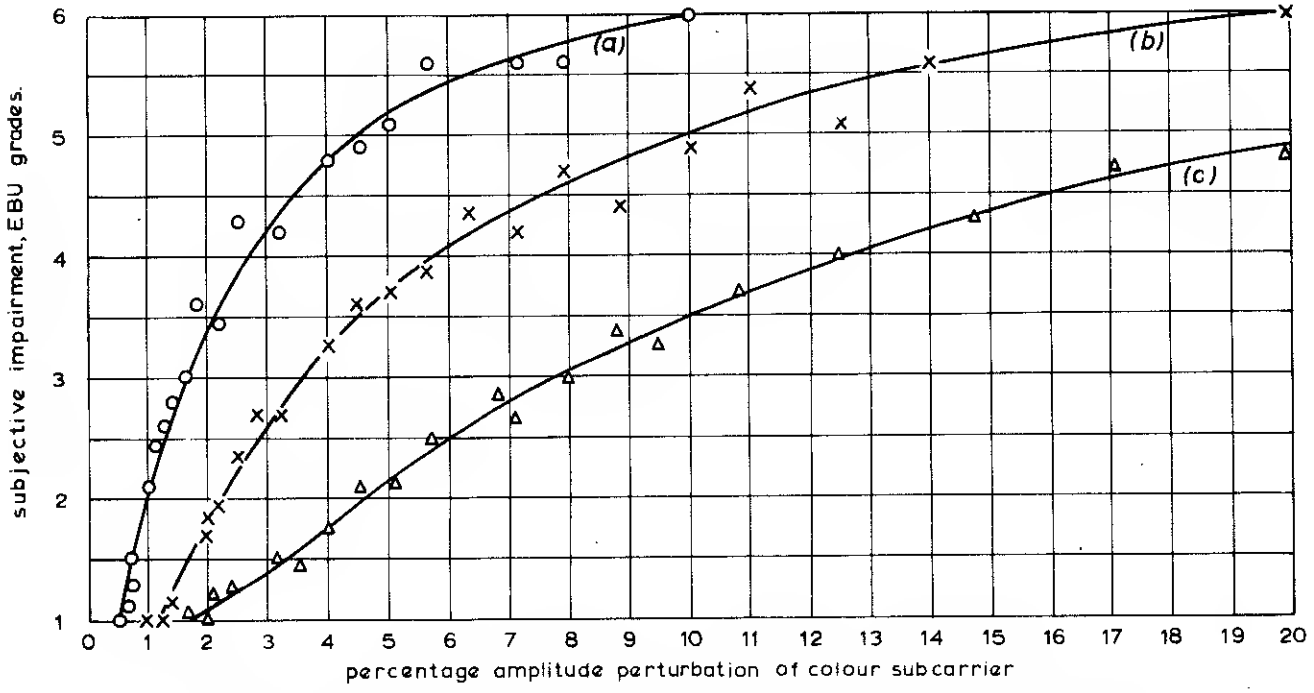

Fig. 3 - Colour picture impairment due to perturbation of amplitude of colour subcarrier

(*a*) 100% amplitude, 95% saturated colour bars
(*b*) 'USA 2, Gloved ski-girl holding pole'
(*c*) 'EBU 1, Boy with toys'

4. CONCLUSIONS

The impairment caused by systematic amplitude perturbations of the colour subcarrier in a colour television system of the NTSC type has been determined by means of subjective tests. Similar results would be expected in the PAL television system. The results do not apply to amplitude errors in general since the picture impairment pattern used was that due to one of the particular switching waveforms used in the Mk 2A Field-Store Standards Converter. It is thought probable, however, that the results given in this report represent the worst case of a systematic amplitude-error impairment.

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